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(54) Title: ABSORBANT FIBERS CAPABLE OF SPONTANEOUSLY TRANSPORTING FLUIDS

Wicking Direction of Fluid

(57) Abstract

Disclosed are coated fibers that are capable of absorbing and spontaneously transporting certain fluids, for example aqueous fluids, such as water, on their surfaces. The coated fibers are coated with a superabsorbant polymer. The coated fibers, especially in the form of tow, can be incorporated into absorbant articles, such as diapers.

- 1 -

ABSORBANT FIBERS CAPABLE OF SPONTANEOUSLY
TRANSPORTING FLUIDS

This application is a continuation-in-part of
5   application Serial No. 333,651, filed April 4, 1989.

Field of the Invention
This invention concerns absorbant fibers that are
capable of spontaneously transporting water on their
10   surfaces and useful structures made from such fibers.

Background of the Invention
Presently available absorbant articles such as
diapers, sanitary napkins, incontinence briefs, and the
15   like are generally very good at absorbing aqueous
fluids such as urine and blood. However, during
typical use such articles become saturated at the
impingement zone while other zones removed from the
impingement zone will remain dry. As a result, a
20   substantial portion of the total absorbant capabilities
of such articles remains unused. Thus, it would be
highly desirable to have a means for transporting the
aqueous fluids from the impingement zone to other areas
of the absorbant article to more fully utilize the
25   article's total absorbant capability. In copending
application Serial No. 333,651, incorporated herein by
reference in its entirety, such a means of fluid
transport by use of certain fibers is disclosed.
The ability to transport liquids (alternately
30   referred to herein as "wickability") and to hold
liquids are two important features of absorbant cores
of sanitary consumer disposables such as diapers, adult
incontinent products, and feminine hygiene products.
Absorbant cores are designed to wick fluids as far as
35   possible to prevent leakage and optimize the use of

- 2 -

absorbant material. In a conventional diaper, fluid is
wicked by capillary action through the porous fluff
pulp core. Liquid holding capacity is largely within
the pores of the fluff pulp but is also enhanced by the
5   addition of superabsorbant polymers to the absorbant
core. These superabsorbant polymers are especially
beneficial for holding liquids under pressure compared
to pulp alone. Absorbant cores of diapers and adult
incontinent products do not sufficiently wick fluids
10 from the crotch area to entirely prevent leaking.
Typically 3—7% of diapers and 33—40% of adult
incontinent products leak. Leaking is the number one
customer complaint about these products. Solving the
leaking problem is high priority among the
15 manufacturers of these products.

     In the prior art thermally bonded webs composed of
polyester, polypropylene, or polyethylene hydrophobic
fibers are formed. These webs are subsequently coated
with acrylic acid partially neutralized by alkali
20 metallic salts and crosslinked simultaneously with
polymerization to form webs coated in situ with
superabsorbant polymer (European Patent Application
0 223 908). The webs have increased absorption of
fluid when used in a sanitary product such as a diaper,
25 but the individual fibers of the web do not possess the
ability to wick fluid from the crotch area (which is
most prone to leaking) to lesser utilized areas of the
absorbant core.

     Japanese Patent Laid—Open No. 204,975/1984
30 describes the coating of cellulose fiber based material
with a water soluble monomer which is converted into a
water—absorptive polymer. According to U.S. Patent
4,721,647 this type of material has poor absorption
performance because the monomer is able to penetrate
35 inside the fiber base material and fill the capillaries

— 3 —

between filaments. The mode of wicking in this prior
art is totally in the capillaries between the fibers.
The diameter of the capillaries is reduced by the
coating. As the coating swells in the wet state the
5   capillaries are blocked off.

We have discovered spontaneously transportable
fibers coated with superabsorbing polymers which are
capable of absorbing liquid as well as transporting
liquid.

10

Summary of the Invention
The present invention is directed to a synthetic
absorbant, coated, fiber which is capable of
spontaneously transporting water on the surface
15   thereof.

The fiber of the present invention has at least
one continuous groove oriented axially along the fiber
and said fiber satisfies the following equation
$$(1-X \cos \theta_a) < 0,$$
20   wherein

θ_a is the advancing contact angle of water
measured on a flat film made from the same
material as the fiber and having the same surface
treatment, if any,

25   X is a shape factor of the fiber
cross-section that satisfies the following
equation
$$X = \frac{P_w}{4r + (\pi-2)D}$$

30   wherein

P_w is the wetted perimeter of the fiber and
r is the radius of the circumscribed circle
circumscribing the fiber cross-section and D is
the minor axis dimension across the fiber
35   cross-section,

— 4 —

wherein said fiber has coated thereon at least one
superabsorbant polymer.

It is preferred that the fiber of the invention
satisfies the formula:

5

$$\gamma_{LA} \cdot \frac{12\pi \cdot 10^{-4}}{\sqrt{\rho}} \cdot \sqrt{dpf} \cdot (1{-}X \cos \theta_a) \leq -0.3,$$

wherein γ_{LA} is the surface tension of water in air
in dynes/cm, ρ is the fiber density in grams/cc,
and dpf is the denier of the single fiber.

10   It is preferred that X is greater than 1.2, more
preferably greater than about 2.5, most preferably
greater than about 4.

Brief Description of the Drawings.

15   Figure 1 — schematic representation of a three
dimensional view of an absorbant fiber of the invention
illustrating the swelling of superabsorbant material
out of a fiber groove upon transport of a fluid.

Figure 2A — illustration of the behavior of a drop
20 of an aqueous fluid which has just contacted a fiber
that is spontaneously transportable at time = 0. The
arrows labelled "LFA" indicate the location of the
liquid–fiber–air interface.

Figure 2B — illustration of the behavior of a drop
25 of an aqueous fluid on a fiber that is spontaneously
transportable at time = t_1 (t_1 >0). The arrows
labelled "LFA" indicate the location of the liquid–
fiber–air interface.

Figure 2C — illustration of the behavior of a drop
30 of an aqueous fluid on a fiber that is spontaneously
transportable at time = t_2 (t_2 >t_1). The arrows
labelled "LFA" indicate the location of the
liquid–fiber–air interface.

Figure 3 – schematic representation of an orifice of a spinneret useful for producing a spontaneously transportable fiber.

Figure 4 – schematic representation of an orifice
5   of a spinneret useful for producing a spontaneously transportable fiber.

Figure 5 – schematic representation of an orifice of a spinneret useful for producing a spontaneously transportable fiber.

10   Figure 6 – schematic representation of an orifice of a spinneret useful for producing a spontaneously transportable fiber.

Figure 6B – schematic representation of an orifice of a spinneret useful for producing a spontaneously
15   transportable fiber.

Figure 7 – schematic representation of an orifice of a spinneret having 2 repeating units, joined end to end, of the orifice as shown in Figure 3.

Figure 8 – schematic representation of an orifice
20   of a spinneret having 4 repeating units, joined end to end, of the orifice as shown in Figure 3.

Figure 9 – photomicrograph of a poly(ethylene terephthalate) fiber cross-section made using a spinneret having an orifice as illustrated in Figure 3
25   (specific dimensions of spinneret orifice described in Example 1).

Figure 10 – photomicrograph of a polypropylene fiber cross-section made using a spinneret having an orifice as illustrated in Figure 3 (specific dimensions
30   of spinneret orifice described in Example 2).

Figure 11 – photomicrograph of a nylon 66 fiber cross-section made using a spinneret having an orifice as illustrated in Figure 3 (specific dimensions of spinneret orifice described in Example 2).

Figure 12 - schematic representation of a
poly(ethylene terephthalate) fiber cross-section made
using a spinneret having an orifice as illustrated in
Figure 4 (specific dimensions of spinneret orifice
5   described in Example 8).

Figure 13 - photomicrograph of a poly(ethylene
terephthalate) fiber cross-section made using a
spinneret having an orifice as illustrated in Figure 5
(specific dimensions of spinneret orifice described in
10 Example 9).

Figure 14 - photomicrograph of a poly(ethylene
terephthalate) fiber cross-section made using a
spinneret having an orifice as illustrated in Figure 7
(specific dimensions of spinneret orifice described in
15 Example 10).

Figure 15 - photomicrograph of a poly(ethylene
terephthalate) fiber cross-section made using a
spinneret having an orifice as illustrated in Figure 8
(specific dimensions of spinneret orifice described in
20 Example 11).

Figure 16 - schematic representation of a fiber
cross-section made using a spinneret having an orifice
as illustrated in Figure 3 (Example 1). Exemplified is
a typical means of determining the shape factor X.

25   Figure 17 - photomicrograph of a poly(ethylene
terephthalate) fiber cross-section made using a
spinneret having an orifice as illustrated in Figure 6
(specific dimensions of spinneret orifice described in
Example 12).

30   Figure 17B - schematic representation of a
poly(ethylene terephthalate) fiber cross-section made
using a spinneret having an orifice as illustrated in
Figure 6B (specific dimensions of spinneret orifice
described in Example 13).

35

- 7 -

Detailed Description of the Invention

As used herein, the term "base fibers" means the
fibers disclosed in Serial No. 333,651 not having a
superabsorbant polymer coating (but optionally having a
5   different surface treatment, e.g., a coating of a
hydrophilic lubricant), and the terms "coated fiber",
"absorbant fiber", or "coated, absorbant fiber" mean a
fiber of the present invention, i.e., a base fiber
having coated thereon at least one superabsorbant
10   polymer.

The three important variables fundamental to the
liquid transport behavior are (a) surface tension of
the liquid, (b) wettability or the contact angle of the
solid with the liquid, and (c) the geometry of the
15   solid surface. Typically, the wettability of a solid
surface by a liquid can be characterized by the contact
angle that the liquid surface (gas—liquid interface)
makes with the solid surface (gas—solid surface).
Typically, a drop of liquid placed on a solid surface
20   makes a contact angle, θ, with the solid surface. If
this contact angle is less than 90°, then the solid is
considered to be wet by the liquid. However, if the
contact angle is greater than 90°, such as with water
on Teflon (trademark) surface, the solid is not wet by
25   the liquid. Thus, it is desired to have a minimum
contact angle for enhanced wetting, but definitely, it
must be less than 90°. However, the contact angle also
depends on surface inhomogeneities (chemical and
physical, such as roughness), contamination,
30   chemical/physical treatment of the solid surface, as
well as the nature of the liquid surface and its
contamination. Surface free energy of the solid also
influences the wetting behavior. The lower the surface
energy of the solid, the more difficult it is to wet
35   the solid by liquids having high surface tension.

Thus, for example, Teflon, which has low surface energy does not wet with water. (Contact angle for Teflon-water system is 112°.) However, it is possible to treat the surface of Teflon with a monomolecular

5 film of protein, which significantly enhances the wetting behavior. Thus, it is possible to modify the surface energy of fiber surfaces by appropriate lubricants/finishes to enhance liquid transport. The contact angle of polyethylene terephthalate (PET),

10 nylon 66, and polypropylene with water is 80°, 71°, and 108°, respectively. Thus, nylon 66 is more wettable than PET. However, for polypropylene, the contact angle is >90°, and thus is nonwettable with water.

The second property of fundamental importance to

15 the phenomena of liquid transport is surface tension of the liquid.

The third property of fundamental importance to the phenomena of liquid transport is the geometry of the solid surface. Although it is known that grooves

20 enhance fluid transport in general, we have discovered particular geometries and arrangements of deep and narrow grooves on fibers and treatments thereof which allow for the spontaneous surface transport of aqueous fluids in single fibers. Thus we have discovered

25 fibers with a combination of properties wherein an individual fiber is capable of spontaneously trans- porting water on its surface.

The particular geometry of the deep and narrow grooves is very important. For example, in grooves

30 which have the feature that the width of the groove at any depth is equal to or less than the width of the groove at the mouth of the groove are preferred over those grooves which do not meet this criterion. If the preferred groove is not achieved "bridging" of the

35 liquid across the restriction is possible and thereby

the effective wetted perimeter (Pw) is reduced.
Accordingly, it is preferred that Pw is substantially
equal to the geometric perimeter.

The number of continuous grooves present in the
5 fiber of the present invention is not critical as long
as the required geometry is present (i.e., the fiber
satisfies the equation $(1-X \cos \theta_a) < 0$). Typically
there are at least 2 grooves present, and preferably
less than 10.

10 "Spontaneously transportable" and derivative terms
thereof refer to the behavior of a fluid in general and
in particular a drop of fluid, typically water, when it
is brought into contact with a single fiber such that
the drop spreads along the fiber. Such behavior is
15 contrasted with the normal behavior of the drop which
forms a static ellipsoidal shape with a unique contact
angle at the intersection of the liquid and the solid
fiber. It is obvious that the formation of the
ellipsoidal drop takes a very short time but remains
20 stationary thereafter. Figures 2A, 2B and 2C
illustrate spontaneous fluid transport on a fiber
surface. The key factor is the movement of the
location of the air, liquid, solid interface with time.
If such interface moves just after contact of the
25 liquid with the fiber, then the fiber is spontaneously
transportable; if such interface is stationary, the
fiber is not spontaneously transportable. The
spontaneously transportable phenomenon is easily
visible to the naked eye for large filaments (>20
30 denier per filament (dpf) or >22.22 dtex) but a
microscope may be necessary to view the fibers if they
are less than 20 dpf (<22.22 dtex). Colored fluids are
more easily seen but the spontaneously transportable
phenomenon is not dependent on the color. It is
35 possible to have sections of the circumference of the

fiber on which the fluid moves faster than other
sections. In such case the air, liquid, solid
interface actually extends over a length of the fiber.
Thus, such fibers are also spontaneously transportable

5   in that the air, liquid, solid interface is moving as
opposed to stationary.

Spontaneous transportability is basically a
surface phenomenon; that is the movement of the fluid
occurs on the surface of the fiber. However, it is

10   possible and may in some cases be desirable to have the
spontaneously transportable phenomenon occur in
conjunction with absorption of the fluid into the
fiber. The behavior visible to the naked eye will
depend on the relative rate of absorption vs.

15   spontaneous transportability. For example, if the
relative rate of absorption is large such that most of
the fluid is absorbed into the fiber, the liquid drop
will disappear with very little movement of the air,
liquid, solid interface along the fiber surface whereas

20   if the rate of absorption is small compared to the rate
of spontaneous transportability the observed behavior
will be that of wicking or transport, as exemplified in
Figures 2A through 2C. In Figure 2A, a drop of aqueous
fluid is just placed on the fiber (time = 0). In

25   Figure 2B, a time interval has elapsed (time = t_1) and
the fluid starts to be spontaneously transported. In
Figure 2C, a second time interval has passed (time =
t_2) and the fluid has been spontaneously transported
along the fiber surface further than at time = t_1.

30   A base fiber or a coated fiber of the present
invention is capable of spontaneously transporting
water on the surface thereof. Distilled water can be
employed to test the spontaneous transportability
phenomenon; however, it is often desirable to

35   incorporate a minor amount of a colorant into the water

- 11 -

to better visualize the spontaneous transport of the
water, so long as the water with colorant behaves
substantially the same as pure water under test
conditions. We have found aqueous Syltint Poly Red

5 (trademark) from Milliken Chemicals to be a useful
solution to test the spontaneous transportability
phenomenon. The Syltint Poly Red solution can be used
undiluted or diluted significantly, e.g., up to about
50x with water.

10   In addition to being capable of transporting
water, a base fiber or a coated fiber of the present
invention is also capable of spontaneously transporting
a multitude of other aqueous fluids. Aqueous fluids
are those fluids comprising about 50% or more water by

15 weight, preferred is about 75% or more water by weight,
most preferred is about 90% or more water by weight.
Preferred aqueous fluids are body fluids, especially
human body fluids. Such preferred fluids include, but
are not limited to, blood, urine, perspiration, and the

20 like. Other preferred aqueous fluids include, for
example, aqueous inks.
     In addition to being able to transport aqueous
fluids, a base fiber or coated fiber of the present
invention is also capable of transporting an alcoholic

25 fluid on its surface. Alcoholic fluids are those
fluids comprising greater than about 50% by weight of
an alcoholic compound of the formula

R—OH

wherein R is an aliphatic or aromatic group containing

30 up to 12 carbon atoms. It is preferred that R is an
alkyl group of 1 to 6 carbon atoms, more preferred is 1
to 4 carbon atoms. Examples of alcohols include
methanol, ethanol, n-propanol and iso-propanol.
Preferred alcoholic fluids comprise about 70% or more

35 by weight of a suitable alcohol. Preferred alcoholic

fluids include antimicrobial agents, such as
disinfectants, and alcohol-based inks.

The superabsorbant coating of the coated fiber of
the present invention acts as a "sink" and absorbs
5   whatever fluid is being transported.

The absorbant fibers of the present invention are
coated with at least one superabsorbant material. By
the word "coated" and derivative terms thereof is meant
that the superabsorbant material is in a continuous
10 phase and completely surrounds the circumference of a
fiber cross-section for at least a portion of the fiber
length. Different embodiments of the coating include
wherein the entire fiber is substantially coated and
wherein the fiber is only intermittently coated. This
15 intermittent coating provides segments which will wick
fluid without absorbing it to areas which are coated
with superabsorbant polymer and will absorb the fluid
in a preferred area. Which specific embodiment is
preferred will depend upon the particular desired
20 application. A particular preferred embodiment is
wherein the fiber of the present invention is
substantially the length of an absorbant article (e.g.,
a diaper, an incontinent pad, or the like) and is
coated on the ends of the fiber, but not in the center
25 portion.

Also, in the coated fibers of the invention, the
coating is in intimate contact with at least a portion
of the fiber surface. Preferably, substantially the
entire coating which is positioned adjacent to the
30 fiber surface is in intimate contact with that portion
of the fiber surface. That is, preferably all the
groove surfaces are "filled" and no visible gaps appear
between the coating and the fiber surface upon routine
examination by microscopy at a magnification of about
35 20X.

Water soluble polymerizable monomers such as acrylic acid, methacrylic acid, and vinylsulfonic acid of which 20% or more of the carboxyl groups have been neutralized into an alkali metal salt can be used to
5 form the superabsorbant coating on the base fibers. Preferred superabsorbant polymers are those formed which have a crosslinked structure. Water soluble crosslinking agents having two or more functional groups capable of reacting with a functional group of
10 the aforementioned acids can be used. They are well known in the art. N,N'-methylene bisacrylamide, ethylene glycol bisacrylate, and polyglycidyl ethers are typical examples. The polymerization is carried out _in situ_, i.e., in the presence of the base fibers.
15 The polymerization can be accomplished through thermal, light, accelerated electron beams, radiation, ultraviolet rays. It is necessary to add a water soluble radical polymerization initiator, in thermal polymerization, or a water-soluble initiator capable of
20 generating radicals with the aid of light or ultra- violet rays in photopolymerization or ultra violet polymerization to the aqueous monomer solution. Initiators are well known in the art (see U.S. Patent 4,721,647). The degree of crosslinking can be
25 varied to control the amount and rate of absorption to the extent that the superabsorbant polymer remains water insoluble. The amount of superabsorbant polymer coating can be varied. It is preferred that the amount be limited so that individual filaments are not bonded
30 together or that the swollen gel is prevented from leaving the grooves of the filaments.

Generally, the methodology taught in U.S. Patent 4,721,647 (incorporated herein by reference in its entirety) and European Patent Application 0 188 091
35 can be used to prepare the coated absorbant fibers of

the present invention except that one would substitute
the spontaneously transportable fibers of Serial
No. 333,651, (i.e., the base fibers) for the fiber used
in the prior art methods.

5   A prior art example (European Patent Application
0 188 091) discloses non-woven webs having a thin
superabsorbant polymeric coating on the individual
fibers of the web. The fibers of this web are round
cross-section fibers such as Kodel (trademark) 431

10   polyester (available from Eastman Chemical
Products, Inc., Kingsport, Tennessee, U.S.A.). The
aforementioned disclosure attempts to solve the problem
of gel blocking which occurs in some absorbant products
where the superabsorbant polymer in granule form is

15   layered within absorbant core. As the superabsorbant
polymer granules absorb fluid they swell. Liquid
transport through the swollen gel is limited primarily
to the slow rates of diffusion. The European Patent
Application 0 188 091 attempts to solve this barrier

20   problem of swollen gels by uniformly dispersing the
superabsorbant polymer throughout the web as a
uniformly thin coated film on the fibers. The claim is
that they will not block fluid transport throughout the
remainder of the open network structure of the web.

25   The thinly coated fibers of 0 188 091 only absorb fluid
in the coating. They do not wick fluid. These webs
are dependent on the capillary action of the pores
between the fibers for wicking action. The coated
fibers, filaments, or webs coated with superabsorbant

30   polymer of this invention unexpectedly both wick and
absorb fluid.

       The problem of blocking capillary wicking action
between superabsorbant coated hydrophilic fiber base
materials discussed in U.S. Patent 4,721,647 is not a

35   problem in the present invention since the wicking

action does not depend solely on capillary action
between filaments. Furthermore, substantial uniform
coating of monomer solution is accomplished within the
grooves of the base fibers as opposed to outer
5   perimeter and between filaments of the prior art
hydrophilic fibers.

The liquid transport of the base fibers is
attributed to having a desired combination of
hydrophilic coating and surface geometry. One would
10 expect that coating these fibers with superabsorbant
polymer (especially using amounts of polymer which
completely fill the grooves of the base fibers) would
destroy the preferred geometry of the filament
necessary for liquid transport. Unexpectedly when
15 these base fibers which have been coated with super-
absorbant polymer are subjected to a fluid such as
water or synthetic urine, the superabsorbant polymer
filling the grooves is observed to swell as it absorbs
fluid. The swollen gel pops out of the grooves
20 sufficient to allow the fluid to wick down the open
groove until it contacts additional superabsorbant.
The process is repeated continuously until the super-
absorbant is consumed or the end of the filament is
reached. Although it is not desired to be bound by any
25 particular mechanism, it is believed that the
hydrophilic coating initially placed on the base fibers
is not destroyed by the superabsorbant polymer coating
and the desired geometry of the grooves is restored as
the superabsorbant polymer swells and moves out of the
30 grooves. Also it is believed that no bonding occurs
between the superabsorbant polymer coating and the
fiber surface to hold the gel. A cross-sectional
schematic of a single base fiber having a groove filled
with superabsorbant polymer is shown in Figure 1. The
35 superabsorbant polymer is shown as it swells and pops

— 16 —

out of the groove. This action allows room for more
fluid to enter and wick in the groove.

The base fibers can be comprised of any material
known in the art capable of having a cross-section of
5 . the desired geometry. Preferred materials for use in
the present invention are polyesters.

The preferred polyester materials useful in the
present invention are polyesters or copolyesters that
are well known in the art and can be prepared using
10   standard techniques, such as, by polymerizing
dicarboxylic acids or esters thereof and glycols. The
dicarboxylic acid compounds used in the production of
polyesters and copolyesters are well known to those
skilled in the art and illustratively include
15   terephthalic acid, isophthalic acid, p,p'-diphenyl-
dicarboxylic acid, p,p'-dicarboxydiphenyl ethane,
p,p'-dicarboxydiphenyl hexane, p,p'-dicarboxydiphenyl
ether, p,p'-dicarboxyphenoxy ethane, and the like, and
the dialkylesters thereof that contain from 1 to about
20   5 carbon atoms in the alkyl groups thereof.

Suitable aliphatic glycols for the production of
polyesters and copolyesters are the acyclic and
alicyclic aliphatic glycols having from 2 to 10 carbon
atoms, especially those represented by the general
25   formula $HO(CH_2)_pOH$, wherein p is an integer having a
value of from 2 to about 10, such as ethylene glycol,
trimethylene glycol, tetramethylene glycol, and
pentamethylene glycol, decamethylene glycol, and the
like.
30   Other known suitable aliphatic glycols include
1,4-cyclohexanedimethanol, 3-ethyl-1,5-pentanediol,
1,4-xylylene, glycol, 2,2,4,4-tetramethyl-1,3-cyclo-
butanediol, and the like. One can also have present a
hydroxylcarboxyl compound such as 4,-hydroxybenzoic
35   acid, 4-hydroxyethoxybenzoic acid, or any of the other

- 17 -

hydroxylcarboxyl compounds known as useful to those
skilled in the art.

It is also known that mixtures of the above
dicarboxylic acid compounds or mixtures of the
5   aliphatic glycols can be used and that a minor amount
of the dicarboxylic acid component, generally up to
about 10 mole percent, can be replaced by other acids
or modifiers such as adipic acid, sebacic acid, or the
esters thereof, or with modifiers that impart improved
10   dyeability to the polymers. In addition one can also
include pigments, delusterants or optical brighteners
by the known procedures and in the known amounts.

The most preferred polyester for use in preparing
the base fiber is poly(ethylene terephthalate) (PET).
15   Other materials that can be used to make the base
fibers include polyamides such as a nylon, e.g.,
nylon 66 or nylon 6; polypropylene; polyethylene; and
cellulose esters such as cellulose triacetate or
cellulose diacetate.
20   A single base fiber or coated fiber of the present
invention preferably has a denier of between about 3
and about 1,000 (about 3.33×10^{-7} and about 1.11 x
10^{-4} kg/m), more preferred is between about 10 and
about 70 (about 1.11×10^{-6} and about 7.78×10^{-6}
25   kg/m).

The base fibers preferably have a surface treat-
ment applied thereto (prior to coating with the super-
absorbant polymer). Such surface treatment may or may
not be critical to obtain the required spontaneous
30   transportability property. The nature and criticality
of such surface treatment for any given fiber can be
determined by a skilled artisan through routine
experimentation using techniques known in the art
and/or disclosed herein. A preferred surface treatment
35   is a coating of a hydrophilic lubricant on the surface

- 18 -

of the fiber. Such coating is typically uniformly
applied at about a level of at least 0.05 weight
percent, with about 0.1 to about 2 weight percent being
preferred. Preferred hydrophilic lubricants include a
5   potassium lauryl phosphate based lubricant comprising
about 70 weight percent poly(ethylene glycol) 600
monolaurate. Another surface treatment is to subject
the fibers to oxygen plasma treatment, as taught in,
for example, Plastics Finishing and Decoration,
10 Chapter 4, Ed. Don Satas, Van Nostrand Reinhold Company
(1986).

Figures 3 through 8 illustrate spinneret orifices
which will prepare fibers of a geometry suitable for
use in the present invention.

15   In Figure 3, W is between 0.064 millimeters (mm)

and 0.12 mm. X_2 is $4W \, ^{+4W}_{-1W}$; X_4 is $2W \pm 0.5W$; X_6 is

$6W \, ^{+4W}_{-2W}$; X_8 is $6W \, ^{+5W}_{-2W}$; X_{10} is $7W \, ^{+5W}_{-2W}$; X_{12} is $9W \, ^{+5W}_{-1W}$;

X_{14} is $10W \, ^{+5W}_{-2W}$; X_{16} is $11W \, ^{+5W}_{-2W}$; X_{18} is $6W \, ^{+5W}_{-2W}$; θ_2 is

$30° \pm 30°$; θ_4 is $45° \pm 45°$; θ_6 is $30° \pm 30°$; and θ_8 is

20 $45° \pm 45°$.

In Figure 4, W is between 0.064 mm and 0.12 mm;

X_{20} is $17W \, ^{+5W}_{-2W}$; X_{22} is $3W \pm W$; X_{24} is $4W \pm 2W$; X_{26} is

$60W \, ^{+8W}_{-4W}$; X_{28} is $17W \, ^{+5W}_{-2W}$; X_{30} is $2W \pm 0.5W$; X_{32} is

$72W \, ^{+10W}_{-5W}$; and θ_{10} is $45° \pm 15°$. In addition, each

25 Leg B can vary in length from 0 to $\dfrac{X_{26}}{2}$; and each

Leg A can vary in length from 0 to

$$\tan (90 - \theta_{10}) \left[\frac{X_{26}}{2} - X_{24} \right] .$$

therefore, the same dimension for Figure 3 applies to
Figure 8.

Figure 16 illustrates the method for determining
the shape factor, X, of the fiber cross-section. In
5   Figure 16, r = 37.5 mm, P_w = 355.1 mm, D = 49.6 mm;
thus, for the fiber cross-section of Figure 16:

$$X = \frac{355.1}{4 \times 37.5 + (\pi - 2)\ 49.6} = 1.72$$

10 The coated fibers of the present invention are
preferably incorporated into an absorbant article in
which it is desired to move or transport aqueous
fluids. Such absorbant articles include, but are not
limited to, diapers, incontinence pads, feminine
15 hygiene articles such as tampons, wipes, and the like.
By use of the coated fibers of the invention, the prior
art problem of leaking can be eliminated or at least
minimized.

The coated fibers of the present invention can be
20 in the form of crimped or uncrimped tows, webs, or
staple fibers comprising a plurality of the coated
fibers of the present invention. A tow of the
invention preferably has a denier of about 10,000 to
about 400,000 (1.11 x 10^{-3} to 4.44 x 10^{-2} kg/m).

25 An absorbant article of the present invention
comprises two or more coated fibers of the present
invention wherein at least part of said fibers are
located near the center of said absorbant article and
at least part of same said fibers are located away from
30 the center of said absorbant article; and wherein said
fibers are capable of being in contact with an aqueous
fluid for about at least 10 seconds near the center of
said absorbant article. As used in this context, "near
the center" of the absorbant article means the
35 geometric center and the area consisting of 50 area %

- 19 -

In Figure 5, W is between 0.064 mm and 0.12 mm;
X_{34} is 2W ± 0.5W; X_{36} is 58W $^{+20W}_{-10W}$; X_{38} is 24W $^{+20W}_{-6W}$;

θ_{12} is 20° $^{+15°}_{-10°}$; θ_{14} is $\dfrac{180°-2\theta_{12}}{n-1}$; and n =
number of legs per 180° = 2 to 6.

5   In Figure 6, W is between 0.064 mm and 0.12 mm;
X_{42} is 6W $^{+4W}_{-2W}$; X_{44} is 11W ± 5W; X_{46} is 11W ± 5W; X_{48}

is 24W ± 10W; X_{50} is 38W ± 13W; X_{52} is 3W $^{+3W}_{-1W}$; X_{54} is

6W $^{+6W}_{-2W}$; X_{56} is 11W ± 5W; X_{58} is 7W ± 5W; X_{60} is

17W ± 7W; X_{62} is 28W ± 11W; X_{64} is 24W ± 10W; X_{66} is

10   17W ± 7W; X_{68} is 2W ± 0.5W; θ_{16} is 45° $^{+30°}_{-15°}$; θ_{18}

is 45° ± 15°; and θ_{20} is 45° ± 15°.

In Figure 6B W is between 0.064 mm and 0.12 mm,
X_{72} is 8W $^{+4W}_{-2W}$, X_{74} is 8W $^{+4W}_{-2W}$, X_{76} is 12W ± 4W, X_{78} is

8W ± 4W, X_{80} is 24W ± 12W, X_{82} is 18W ± 6W, X_{84} is

15   8W $^{+4W}_{-2W}$, X_{86} is 16W ± 6W, X_{88} is 24W ± 12W, X_{90} is

18W ± 6W, X_{92} is 2W ± 0.5W, θ_{22} is 135° ± 30°, θ_{24} is

90° ± $^{45°}_{30°}$, θ_{26} is 45° ± 15°, θ_{28} is 45° ± 15°, θ_{30} is

45° ± 15°, θ_{32} is 45° ± 15°, θ_{34} is 45° ± 15°, θ_{36} is

45° ± 15°, and θ_{38} is 45° ± 15°.

20   In Figure 7, the depicted spinneret orifice
contains two repeat units of the spinneret orifice
depicted in Figure 3, therefore, the same dimensions
for Figure 3 apply to Figure 7. Likewise, in Figure 8,
the depicted spinneret orifice contains four repeat

25 units of the spinneret orifice depicted in Figure 3,

of the total article immediately surrounding said
geometric center; "away from the center" of the
absorbant article means the remaining 50 area % that is
not near the center of the article. In addition, other
5   sinks (i.e., other than the superabsorbant polymer
coating) optionally may be in contact with the coated
fibers of the present invention. Preferred other sinks
are fluff pulp, superabsorbant material, and
combinations thereof. It is preferred that such other
10   sinks are in contact with a given fiber near the end of
such fiber in the area away from the center of the
article. As used in this context the term "near the
end" of a fiber refers to an actual end of a fiber or
the area consisting of the end 10% of the length of the
15   fiber.

A preferred absorbant article of the present
invention comprises a diaper or incontinent pad having
a major axis and a minor axis and a length in excess of
a width which comprises a top sheet, a back sheet, and
20   an absorbant core comprising at least one absorbant
layer wherein said article further comprises the tow of
the present invention. The tow may be crimped or
uncrimped.

The tow in said absorbant article can be located
25   in several different positions with several different
spatial orientations. For example, the tow can be
uniformly spread across all or part of the width of the
article and the fibers of the tow can be substantially
parallel to the major axis of the article and extend
30   from about 1/2 to substantially the length of the
article.

Alternatively, the fibers of the tow can be
substantially parallel to the major axis of the diaper
and extend substantially the length of the diaper.

— 22 —

By use of a tow of the coated fibers of the invention in an absorbant article such as a diaper, urine can be transported to a larger surface area on the diaper. Thus, the amount of superabsorbant

5   material required in the diaper can be reduced and the diaper surface will be drier.

By utilizing the fibers of the present invention in a diaper construction, it is preferred that at least one of the following benefits be realized.

10   (i)   The effective surface area of the diaper utilized for urine/aqueous fluid movement will increase by 5% to 30%.

       (ii) The amount of superabsorbant material utilized in the diaper will reduce by 2% to

15   25%.

      (iii) The diaper will be thinner by about 2% to 15%.

       (iv) The strikethrough (seconds)/rewet (grams) responses as measured by the

20   strikethrough/rewet test described in U.S. Patent 4,324,247 are improved with the strikethrough being reduced from about 2 to about 50% and the rewet being reduced from about 2 to about 70% when compared to

25   equivalent structures without the fibers (tow) of this invention being present. This results in the interface between the diaper and the wearer remaining drier.

The coated fibers of the tow can be located in the

30 absorbant article at any place which will result in an overall beneficial effect. For example, the fibers can be located between the top sheet and the absorbant core, incorporated into the absorbant core, between the absorbant core and the back sheet, or multiple

35 combinations of the above.

The top sheet of the absorbant article of the
present invention can be made of any material known in
the art for such use. Such materials include, but are
not limited to, polypropylene, polyethylene, poly-

5   ethylene terephthalate, cellulose or rayon; preferred
is polypropylene. The top sheet is the sheet which is
designed to be in contact with the body during typical
end uses. Such a top sheet is alternatively referred
to in the art as a "facing sheet," and is typically

10 comprised of a web of short and/or long fibers.

The back sheet of the absorbant article of the
present invention can be made of any material known in
the art for such use. Such materials include, but are
not limited to, polyethylene, a polyester, or poly-

15 propylene; preferred is polyethylene. The back sheet
is typically impervious to body fluids such as urine.

The absorbant core of the absorbant article of the
present invention preferably comprises fluff pulp and,
optionally, superabsorbant powder. Fluff pulp is used

20 extensively in the art. Fluff pulp is a batt formed of
loosely compacted short cellulose fibers, such as wood
pulp fibers, or cotton linters, or mixtures thereof,
which are primarily held together by interfiber bonds
usually requiring no added adhesive although

25 thermoplastic binder(s) may also be used. This batt is
a low density coherent web of loosely compacted fibers
preferably comminuted wood pulp fibers. Examples of
absorbant powder are polyacrylates, acrylic acid based
polymers, saponified starch, and polyacrylonitrile

30 graft copolymers.

Other preferred embodiments of the absorbant
article of the present invention include wherein the
coated fibers of the tow are tightly compacted in the
impingement zone such that the fibers are substantially

35 in contact with each other, and toward each end of the

length of the article the fibers of the tow flare and
are substantially not in contact with each other. In
addition, the tow can have from one half to ten turns
of twist in the impingement zone. The terms

5   "impingement zone", "impinging area", and like terms
refer to that area or zone where body fluid first
contacts or impinges the absorbant article during its
intended use. The impingement zone may be near the
center of the absorbant article, away from the center,

10 or overlapping both areas.

It is also contemplated that the coated fibers of
the present invention can be in the form of staple
fiber which may or may not be crimped. When in the
form of staple fiber, a preferred absorbant article of

15 the present invention comprises a diaper or incontinent
pad having a major axis and a minor axis and a length
in excess of a width comprising a top sheet, a back
sheet, and an absorbant core comprising at least one
absorbant layer wherein said core comprises an intimate

20 blend of the staple fiber of the present invention.

Another preferred embodiment of the absorbant
article of the present invention is wherein the article
contains up to three tows of the invention and wherein
the major axis of each tow lies between ±30° around the

25 major axis of the article and wherein the tows lie
either just beneath the top sheet or lie intimately
mixed with the absorbant core or lie adjacent to the
back sheet.

Another preferred embodiment of the absorbant

30 article of the present invention is a two piece diaper
wherein one piece contains tow of the invention and
receives the impinging fluid during the diaper's
intended use and is reusable, and wherein the second
piece is a fluid storage element and is replaceable.

The absorbant article of this invention can optionally contain a tissue or low density spacer layer which is adjacent to the top sheet between the top sheet and absorbant core. In such case the tow

5 preferably lies between the absorbant core and said tissue or density spacer.

In still another preferred embodiment of the absorbant article of the present invention the coated fibers of the tow are in intimate contact with part of

10 the absorbant core located away from the impingement zone.

Other absorbant articles contemplated by the present invention (which may or may not have a specific impingement zone) in which the coated fibers of the

15 present invention can be beneficial include, but are not limited to, a surgical sponge, a wound dressing, a sweat absorbing insole for footwear, and the like.

The base fibers of the present invention can be prepared by techniques taught in Serial No. 333,651

20 and/or as taught herein.

The absorbant articles of the present invention can be made by use of techniques known in the art, for example in U.S. Patents 4,573,986; 3,938,522; 4,102,340; 4,044,768; 4,282,874; 4,285,342; 4,333,463;

25 4,731,066; 4,681,577; 4,685,914; and 4,654,040; and/or by techniques disclosed herein. The tow of the present invention can be incorporated into the absorbant article at any location which will improve fluid movement so as to better utilize the absorbant

30 materials of the article.

The following examples are to illustrate the invention but should not be interpreted as a limitation thereon.

— 26 —

EXAMPLES

Example 1 (Base Fiber Preparation)

Poly(ethylene terephthalate) (PET) polymer of 0.6
5   I.V. was used in this example. I.V. is the inherent
viscosity as measured at 25°C at a polymer concentra-
tion of 0.50 g/100 milliliters (mL) in a suitable
solvent such as a mixture of 60% phenol and 40%
tetrachloroethane by weight. The polymer was dried to
10 a moisture level of ≤ 0.003 weight percent in a
Patterson Conaform dryer at 120°C for a period of 8
hours. The polymer was extruded at 283°C through an
Egan extruder, 1.5-inch (38.16 mm) diameter, with a
length to diameter ratio of 28:1. The fiber was
15 extruded through an eight orifice spinneret wherein
each orifice is as shown in Figure 3 wherein W is 0.084
mm, X_2 is 4W, X_4 is 2W, X_6 is 6W, X_8 is 6W, X_{10} is 7W,
X_{12} is 9W, X_{14} is 10W, X_{16} is 11W, X_{18} is 6W, θ_2 is 0°,
θ_4 is 45°, θ_6 is 30°, and θ_8 is 45°. The polymer
20 throughput was about 7 pounds (lb)/hour (3.18 kg/hour).
The air quench system has a cross-flow configuration.
The quench air velocity at the top of the screen was an
average of 294 feet (ft)/minute (89.61 m/minute). At a
distance of about 7 inches (177.8 mm) from the top of
25 the screen the average velocity of the quench air was
about 285 ft/minute (86.87 m/minute), and at a distance
of about 14 inches (355.6 mm) from the top of the
screen the average quench air velocity was about
279 ft/minute (85.04 m/minute). At about 21 inches
30 (533.4 mm) from the top of the air screen the average
air velocity was about 340 ft/minute (103.63 m/minute).
The rest of the screen was blocked. Spinning lubricant
was applied via ceramic kiss rolls. The lubricant has
a general composition as follows: it is a potassium
35 lauryl phosphate (PLP) based lubricant having

— 27 —

poly(ethylene glycol) 600 monolaurate (70% by weight)
and polyoxyethylene (5) potassium lauryl phosphate (30%
by weight). An emulsion of the above lubricant with
water (90%) was used as the spinning lubricant. The
5   lubricant level on the fiber samples was about 1.5%.
Fibers of 20 dpf (denier per filament) (22.22 dtex)
were wound at 3,000 meters per minute (MPM) on a Barmag
SW4SL winder. A photomicrograph of a cross-section of
this fiber is shown in Figure 9 (150x magnification).
10   The single fiber was tested for spontaneous surface
transportation of an aqueous solution which was aqueous
Syltint Poly Red (obtained from Milliken Chemicals)
which is 80 weight % water and 20 weight % red
colorant. The single fiber of 20 dpf (22.22 dtex)
15   spontaneously surface transported the above aqueous
solution. The following denier per filament (dtex) PET
fibers were also made at different speeds as shown in
Table 1 below:

Table 1

dpf (dtex)	Spin Speed (MPM)	Winder
20 (22.22)	3,000	Barmag
40 (44.44)	1,500	Leesona
60 (66.67)	1,000	Leesona
120 (133.33)	500	Leesona
240 (266.67)	225	Leesona
400 (444.44)	150	Leesona

All the single fibers of above PET fiber with the dpf
30   of 20, 40, 60, 120, 240, and 400 spontaneously surface
transported the aqueous solution of Syltint Poly Red
liquid. The value of the "X" parameter (as defined
hereinbefore) for these fibers was about 1.7. PET film
of 0.02 inch (0.508 mm) thickness was compression
35   molded from the same polymer as that used for making

- 28 -

the above fiber. Contact angle of distilled water on
the above film was measured in air with a contact angle
goniometer. The contact angle was 71.7°. Another
sample of the same film as above was sprayed with the
5 same lubricant as used for making the fiber in this
example at about 1.5% level. The contact angle of
distilled water on the PET film sprayed with the
lubricant was about 7°. Thus, the factor $(1-X \cos \theta)$
in this case is $(1-1.7(\cos 7°)) = -0.69$, which is less
10 than zero.

Example 2 (Base Fiber Preparation)
     Polyhexamethylene adipamide (nylon 66) was
obtained from Du Pont [Zytel (trademark) 42]. The
15 polymer was extruded at 279°C. A spinneret as shown in
Figure 3 was used to form 46 dpf (51.11 dtex) fiber at
255 meters/minute speed. The specific dimensions of
the spinneret orifices were the same as described in
Example 1 except that θ_2 was 30° instead of 0°. The
20 quenching conditions were the same as those for
obtaining PET fiber as in Example 1. A photomicrograph
of the fiber cross-section is shown in Figure 11 (150x
magnification). The lubricant level on the fiber was
about 1.8% by weight. The same lubricant as used in
25 the PET fiber was used (Example 1). This nylon 66
fiber spontaneously transported the aqueous Syltint
Poly Red solution on the fiber surface. The value of
the "X" parameter for this fiber was about 1.9.
Nylon 66 film of 0.02 inch (0.508 mm) thickness was
30 compression molded from the same polymer as that used
for making the fiber of Example 2. Contact angle of
distilled water on the above film was measured in air
with a contact angle goniometer. The contact angle was
64°. Another sample of the same film as above was
35 sprayed with the same lubricant as used for making the

- 29 -

fiber in this example at about the 1.8% level. The
contact angle of distilled water on the nylon 66 film
sprayed with the lubricant was about 2°. Thus, the
factor (1—X cos θ) in this case is (1—1.9(cos 2°)) =
5   —0.9, which is less than zero.

Example 3 (Base Fiber Preparation)

Polypropylene polymer was obtained from Shell
Company (Grade 5C14). It was extruded at 279°C. A
10   spinneret as shown in Figure 3 was used to form 51 dpf
(56.67 dtex) fiber at 2,000 MPM speed. The specific
dimensions of the spinneret orifices were the same as
in Example 2. The quenching conditions were the same
as those for obtaining PET fiber. A photomicrograph of
15   the fiber cross—section is shown in Figure 10 (375x
magnification). The lubricant level on the fiber was
2.6%. The same lubricant as used in PET fiber was used
(Example 1). The polypropylene fiber spontaneously
transported the aqueous Syltint Poly Red solution on
20   the fiber surface. This spontaneously transportable
phenomenon along the fiber surface was also observed
for a 10 dpf (11.11 dtex), single polypropylene fiber.
The value of the "X" parameter for this fiber was
about 2.2. Polypropylene film of 0.02 inch (0.508 mm)
25   thickness was compression molded from the same polymer
as that used for making the above fiber of Example 3.
Contact angle of distilled water on the above film was
measured in air with a contact angle goniometer. The
contact angle was about 110°. Another sample of the
30   same film as above was sprayed with the same lubricant
as used for making the fiber in this example at about
the 2.6% level. The contact angle of distilled water
on the polypropylene film sprayed with the lubricant
was 12°. Thus, the factor (1—X cos θ) in this case is
35   —1.1, which is less than zero.

- 30 -

Example 4 (Base Fiber Preparation)

Cellulose acetate (Eastman Grade CA 398-30,
Class I) was blended with PEG 400 polymer and small
quantities of antioxidant and thermal stabilizer. The
5 blend was melt extruded at 270°C. A spinneret as shown
in Figure 3 was used to form 115 dpf (127.78 dtex)
fiber at 540 meters/minute speed. The specific
dimensions of the spinneret orifices were the same as
in Example 2. No forced quench air was used. The
10 lubricant level on the fiber was 1.6%. The same
lubricant as used in the PET fibers (Example 1) was
used. The cellulose acetate fiber spontaneously
transported the aqueous Syltint Poly Red solution on
the fiber surface. The value of the "X" parameter for
15 this fiber was about 1.8.

Example 5 (Comparative)

PET fiber of Example 1 was made without any
spinning lubricant at 20 dpf (22.22 dtex). A single
20 fiber did not spontaneously transport the aqueous
Syltint Poly Red solution along the fiber surface.

Example 6 (Comparative)

PET fiber of circular cross-section was made. The
25 denier per filament of the fiber was 20 (22.22 dtex).
It had about 1.5% of the lubricant used in Example 1.
A single fiber did not spontaneously transport the
aqueous Syltint Poly Red solution along the fiber
surface.

30

Example 7 (Base Fiber Preparation)

Poly(ethylene terephthalate) (PET) fiber of
Example 5 (without any spinning lubricant) was treated
with oxygen plasma for 30 seconds. Model "Plasmod"
35 oxygen plasma equipment was used. Exciter power is

provided by the RF generator operating at 13.56 MHz
frequency. The plasma treatment was conducted at a
constant level of 50 watts power. The oxygen plasma
treated fiber spontaneously transported the aqueous

5   Syltint Poly Red solution along the fiber. This fiber
was tested again after washing five times and after 3
days and the spontaneously transportable behavior with
the above aqueous solution was still observed. In
order to determine the reduction in contact angle after

10   the plasma treatment, a PET film of the same material
as that of the fiber was subjected to the oxygen plasma
treatment under the same conditions as those used for
the fiber sample. The average contact angle of the
oxygen plasma treated film with distilled water in air

15   was observed to be 26° as measured by a contact angle
goniometer. The corresponding contact angle for the
control PET film (not exposed to the oxygen plasma) was
70°. The significant reduction in contact angle upon
subjecting the untreated PET fiber to the oxygen plasma

20   treatment renders it to be spontaneously surface
transportable for aqueous solutions.

Example 8 (Base Fiber Preparation)

     Poly(ethylene terephthalate) (PET) polymer of 0.6

25   IV was used in this example. It was extruded through a
spinneret having eight orifices as shown in Figure 4
wherein W is 0.084 mm, X_{20} is 17W, X_{22} is 3W, X_{24} is
4W, X_{26} is 60W, X_{28} is 17W, X_{30} is 2W, X_{32} is 72W, θ_{10}
is 45°, Leg B is 30W, and Leg A is 26W. The rest of

30   the processing conditions were the same as those
described in Example 1. A 100 dpf (111.11 dtex) fiber
was spun at 600 MPM. A sketch of the cross-section of
the fiber is shown in Figure 12. The lubricant level
on the fiber was about 1%. The same lubricant as used

35   in Example 1 was used. The above fiber spontaneously

— 32 —

transported the aqueous Syltint Poly Red solution along
the fiber surface. The value of the "X" parameter for
this fiber was 1.5.

5   Example 9 (Base Fiber Preparation)
          Poly(ethylene terephthalate) polymer of 0.6 IV was
used in this example. It was extruded through a
spinneret having eight orifices as shown in Figure 5
wherein W is 0.10 mm, X_{34} is 2W, X_{36} is 58W, X_{38} is
10   24W, θ_{12} is 20°, θ_{14} is 28°, and n is 6. The rest of
the extruding and spinning conditions were the same as
those described in Example 1. A photomicrograph of the
fiber cross-section is shown in Figure 13 (585x
magnification). A 20 dpf (22.22 dtex) fiber was spun
15   at 3000 MPM. The lubricant level on the fiber was
about 1.7%. The same lubricant as used in Example 1
was used. The above fiber spontaneously transported
the aqueous Syltint Poly Red solution along the fiber
surface. The value of the "X" parameter for this fiber
20   was about 2.4.

     Example 10 (Base Fiber Preparation)
          Poly(ethylene terephthalate) (PET) polymer of
about 0.6 IV was used in this example. The polymer
25   was extruded through a spinneret having four orifices
as shown in Figure 7 wherein the dimensions of the
orifices are repeats of the dimensions described in
Example 2. The rest of the processing conditions were
the same as those described in Example 1 unless
30   otherwise stated. A 200 dpf (222.22 dtex) fiber was
spun at 600 MPM. The polymer throughput was about
7 lbs/hr (3.18 kg/hr). An optical photomicrograph of
the fiber is shown in Figure 14 (150x magnification).
The lubricant level on the fiber was 2.0%. The same
35   lubricant as used in Example 1 was used. The above

fiber spontaneously transported the aqueous Syltint
Poly Red solution along the fiber surface. The value
of the "X" parameter for this fiber was about 2.2.

5 Example 11 (Base Fiber Preparation)
       Poly(ethylene terephthalate) (PET) polymer of 0.6
IV was used in this example. The polymer was extruded
through a spinneret having two orifices as shown in
Figure 8 wherein the dimensions of the orifices are
10 repeats of the dimensions described in Example 2. The
rest of the processing conditions were the same as
those described in Example 1. A 364 dpf (404.44 dtex)
fiber was spun at 600 MPM. The cross-section of the
fiber is shown in Figure 15 (150x magnification). The
15 lubricant level on the fiber was about 2.7%. The same
lubricant as used in Example 1 was used. The above
fiber spontaneously transported the aqueous Syltint
Poly Red solution along the fiber surface. The value
of the "X" parameter for this fiber was 2.1.
20

Example 12 (Base Fiber Preparation)
       Poly(ethylene terephthalate) (PET) polymer of 0.6
IV was used in this example. It was extruded through a
spinneret having eight orifices as shown in Figure 6
25 wherein W is 0.10 mm, X_{42} is 6W, X_{44} is 11W, X_{46} is
11W, X_{48} is 24W, X_{50} is 38W, X_{52} is 3W, X_{54} is 6W, X_{56}
is 11W, X_{58} is 7W, X_{60} is 17W, X_{62} is 28W, X_{64} is 24W,
X_{66} is 17W, X_{68} is 2W, θ_{16} is 45°, θ_{18} is 45°, and θ_{20}
is 45°. The rest of the processing conditions were the
30 same as those described in Example 1. A 100 dpf
(111.11 dtex) fiber was spun at 600 MPM. The
cross-section of the fiber is shown in Figure 17. The
lubricant level on the fiber was about 1%. The same
lubricant as used in Example 1 was used. The above
35 fiber spontaneously transported the aqueous Syltint

— 34 —

Poly Red solution along the fiber surface. The value
of the "X" parameter for this fiber was 1.3.

Example 13 (Base Fiber Preparation)

5   PET polymer of 0.6 I.V. is used in this example.
It is extruded through a spinneret having 8 orifices as
shown in Figure 6B wherein W is 0.10 mm, X_{72} is 8W, X_{74}
is 8W, X_{76} is 12W, X_{78} is 8W, X_{80} is 24W, X_{82} is 18W,
X_{84} is 8W, X_{86} is 16W, X_{88} is 24W, X_{90} is 18W, X_{92} is

10   2W, θ_{22} is 135°, θ_{24} is 90°, θ_{26} is 45°, θ_{28} is 45°,
θ_{30} is 45°, θ_{32} is 45°, θ_{34} is 45°, θ_{36} is 45° and θ_{38}
is 45°. A 20 dpf (22.22 dtex) fiber is spun at 3,000
m/min. The rest of the processing conditions are the
same as those used in Example 1. The lubricant level

15   on the fiber is about 1%. The cross-section of the
fiber is shown in Figure 17B. This fiber spontaneously
transports the aqueous Syltint Poly Red solution along
the fiber surface. The "X" value for this fiber is
about 2.1.

20

Example 14 (Example of the Invention)
     500 cc of 45% by weight monomer concentration
sodium acrylate/acrylic acid (75% degree of neutraliza-
tion) water solution were prepared by adding sodium

25   hydroxide to deionized water with ice cooling.
Subsequently acrylic acid was added with ice cooling.
Crosslinking agent (0.862 g) N—N'—methylene bis
acrylamide and initiator (2.29 g) sodium persulfate
were added at room temperature. The above solution was

30   placed in a rotating "kiss" roll applicator.
Continuous filament polyester yarn as prepared in
Example 1 was coated with the above monomer solution
with the applicator operating at 2 rpm and the yarn
speed at 250 fpm (76.20 m/minute) as it contacted the

35   applicator. A small package of yarn was wound (3 min)

- 35 -

and placed in a nitrogen purged oven at 70°C overnight
to polymerize the monomers. The yarn was removed and
the wt % add on of polymer was determined to be 27%.
The above coated yarns were placed in contact with
5   tinted water (diluted Milliken Syltint Poly Red
solution) and observed to simultaneously wick and
absorb the fluid. The swollen gel was observed to move
from the groove of the filament under microscopic
observation.
10

Example 15 (Example of the Invention)
        39 cc of distilled water were placed in a flask.
13.2 grams of sodium hydroxide were added with ice
cooling to the flask. 30 cc of acrylic acid were added
15   to form a clear solution with ice cooling. 0.115 g of
N,N'-methylene bisacrylamide crosslinking agent and
0.316 g of sodium persulfate initiator were added with
heating to 47°C for 10 minutes. A few single filaments
of polyester yarn (15 cm) from yarn as prepared in
20   Example 1 were coated with the above monomer solution
only on one end (about 2.5 cm) with the remaining
12.5 cm left uncoated. The single filaments were
placed in a nitrogen purged oven at 70°C for 20 minutes
to polymerize the monomers. The single filaments were
25   removed from the oven and subjected to tinted water in
the uncoated portion. The fluid was observed to wick
in the uncoated area without absorbing fluid until it
reached the superabsorbant coated area where the fluid
was absorbed by the superabsorbant polymer. As
30   additional fluid was added the polymer formed a swollen
gel which swelled out of the filament grooves thus
allowing more fluid to wick to additional super-
absorbant polymer along the filament. Similar results
were observed when a single filament having the length
35   of an average diaper [i.e., 15 inches (381.0 mm)] was

coated with the monomer solution on both ends of the
filament with the remaining center portion [about 8
inches (203.2 mm)] left uncoated. After polymerizing
the monomer solution on the filaments the uncoated

5   center portion was subjected to the tinted water. The
fluid wicked to the superabsorbant coated ends of the
filament where it was absorbed by the superabsorbant
polymer in the grooves of the coated fiber.

    The invention has been described in detail with

10   particular reference to preferred embodiments thereof,
but it will be understood that variations and modifica-
tions can be effected within the spirit and scope of
the invention. All of the U.S. patents cited herein
are hereby incorporated herein by reference in their

15   entirety.

CLAIMS

We Claim:

5   1. A synthetic coated fiber having at least one
         continuous groove which is capable of
         spontaneously transporting water on the surface
         thereof wherein said fiber satisfies the equation

$$(1-X \cos \theta_a) < 0,$$

10   wherein

         θ_a is the advancing contact angle of water
         measured on a flat film made from the same
         material as the fiber and having the same surface
         treatment, if any,

15   X is a shape factor of the fiber
         cross—section that satisfies the following
         equation

$$X = \frac{P_W}{4r + (\pi-2)D}$$

20   wherein

             P_W is the wetted perimeter of the fiber and
         r is the radius of the circumscribed circle
         circumscribing the fiber cross—section and D is
         the minor axis dimension across the fiber

25   cross—section, and
         wherein

             said fiber has coated thereon at least one
         superabsorbant polymer.

30   2. The coated fiber of Claim 1 wherein $2\frac{r}{D}$ is greater

         than 1.

     3. The coated fiber of Claim 1 wherein $2\frac{r}{D}$ is between

35   1.5 and 5.

— 38 —

4. The coated fiber of Claim 1 which satisfies the equation

$$\gamma_{LA} \cdot \frac{12\pi \cdot 10^{-4}}{\sqrt{\rho}} \cdot \sqrt{dpf} \cdot (1-X \cos \theta_a) \leq -0.3,$$

wherein γ_{LA} is the surface tension of water in air in dynes/cm, ρ is the fiber density in grams/cc, and dpf is the denier of the single fiber.

5. The coated fiber of Claim 1 wherein X is greater than 1.2.

6. The coated fiber of Claim 1 wherein X is greater than 2.5.

7. The coated fiber of Claim 1 wherein X is greater than 4.

8. The coated fiber of Claim 1 having a single fiber denier of between 3 and 1,000 (3.33×10^{-7} and 1.11×10^{-4} kg/m).

9. The coated fiber of Claim 1 having a single fiber denier of between 10 and 70 (1.11×10^{-6} and 7.78×10^{-6} kg/m).

10. The coated fiber of Claim 3 having a single fiber denier of between 10 and 70 (1.11×10^{-6} and 7.78×10^{-6} kg/m).

11. The coated fiber of Claim 1 comprised of a material selected from the group consisting of a polyester, polypropylene, polyethylene, a cellulose ester, and a nylon.

12. The coated fiber of Claim 11 having coated thereon a layer of a hydrophilic lubricant between the fiber surface and the superabsorbant polymer coating.

5

13. The coated fiber of Claim 11 wherein said polyester is poly(ethylene terephthalate) and said hydrophilic lubricant is a potassium lauryl phosphate based lubricant comprising 70 weight

10
percent poly(ethylene glycol) 600 monolaurate which is uniformly applied at a level of at least 0.05% by weight of the total fiber.

14. The coated fiber of Claim 1 comprised of a

15
polyester having coated thereon a layer of a hydrophilic lubricant.

15. The coated fiber of Claim 1 wherein the width of each groove in the fiber cross-section at any

20
depth in the groove is equal to or less than the width of the groove at its mouth.

16. The coated fiber of Claim 1 wherein said super-absorbant polymer is prepared from one or more

25
monomers selected from acrylic acid, methacrylic acid, vinylsulfonic acid, vinylphosphonic acid, and a salt thereof.

17. The coated fiber of Claim 1 wherein the entire

30
fiber is substantially coated with the super-absorbant polymer.

18. The coated fiber of Claim 1 wherein the fiber is coated intermittently with the superabsorbant polymer.

5 19. The coated fiber of Claim 1 wherein the fiber is substantially the length of an absorbant article and is coated on the ends of the fiber, but not in the center portion of the fiber.

10 20. An absorbant article comprising two or more coated fibers of Claim 1.

21. An absorbant article comprising two or more coated fibers of Claim 19.

15

22. The absorbant article of Claim 20 which is a diaper, an incontinent pad, or a feminine hygiene article.

20 23. A tow comprising a plurality of the coated fibers of Claim 1.

24. The tow of Claim 23 having a denier of 10,000 to 400,000 (1.11×10^{-3} to 4.44×10^{-2} kg/m).

25

25. An absorbant article comprising the tow of Claim 23.

Wicking Direction of Fluid

Fig. 1

Time
t=0

LFA

LFA

Fig. 2A

t=t₁ LFA

LFA

Fig. 2B

t=t₂ LFA

LFA
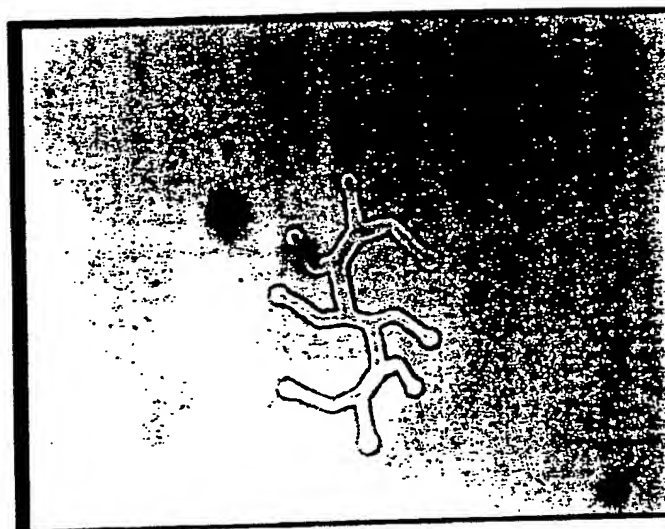
Fig. 2C
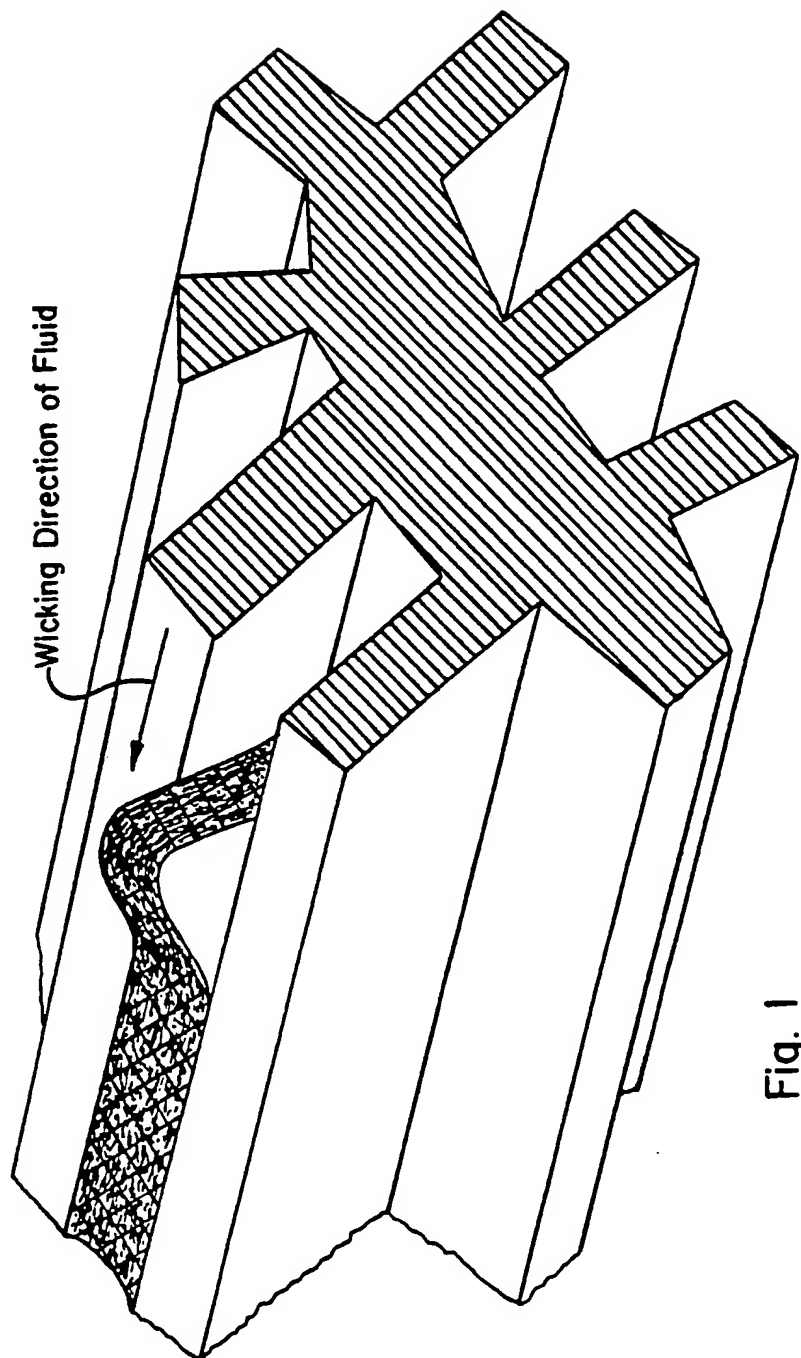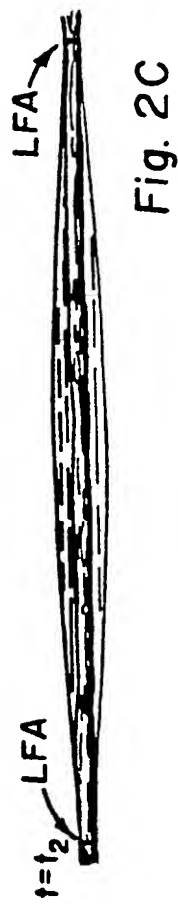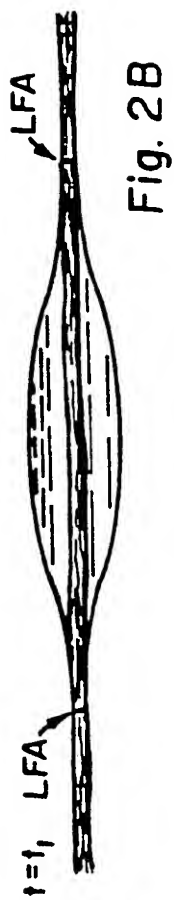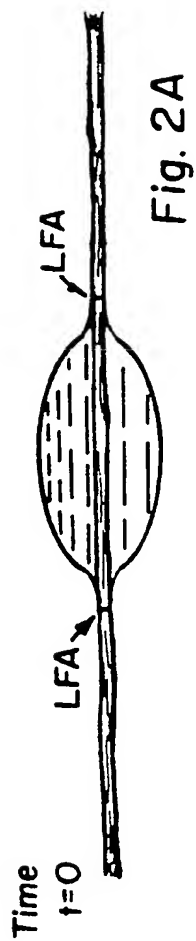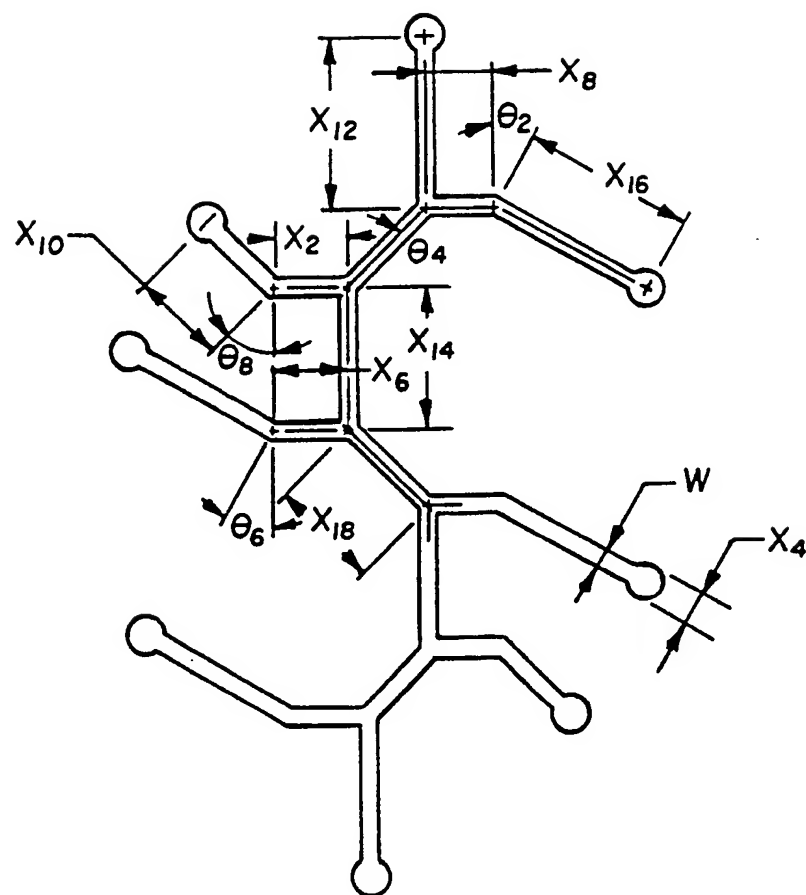
Fig. 3

Fig. 4

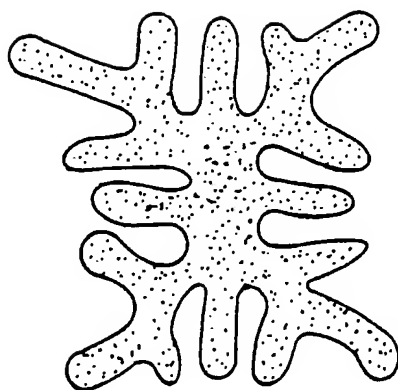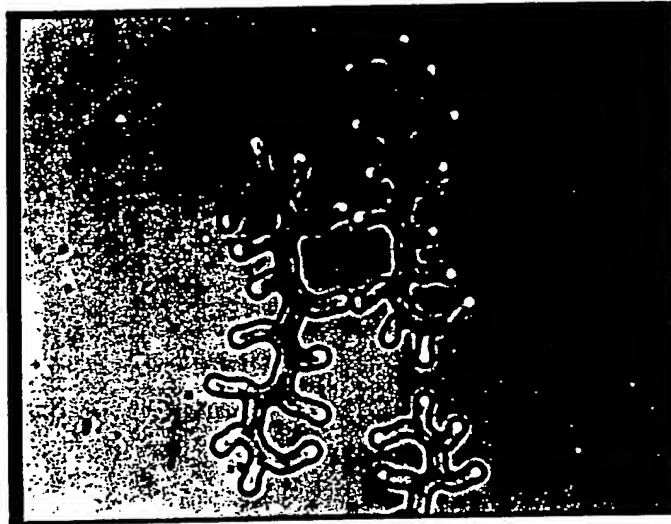Fig. 5

Fig.6

Fig. 6 B

Fig. 7
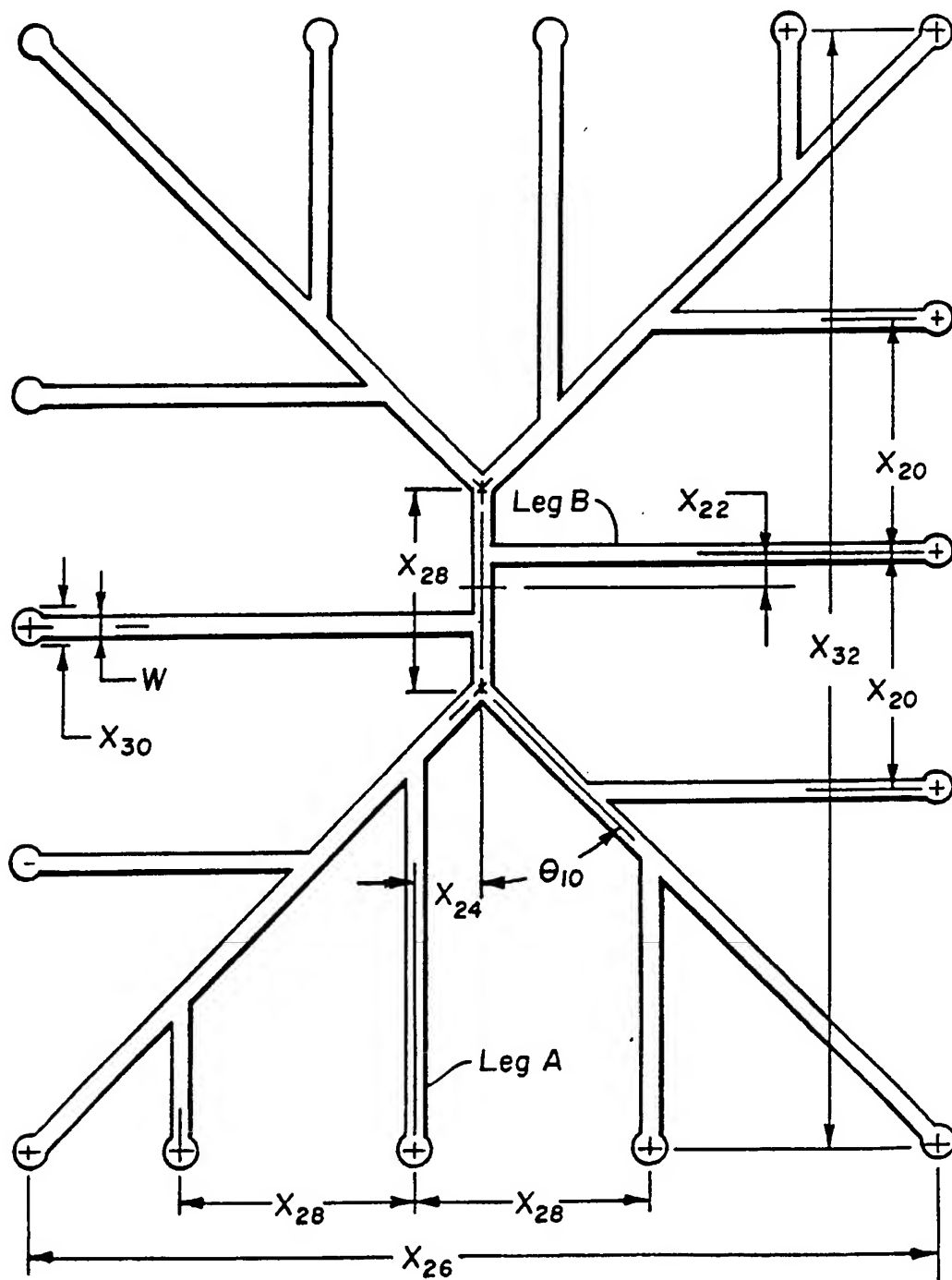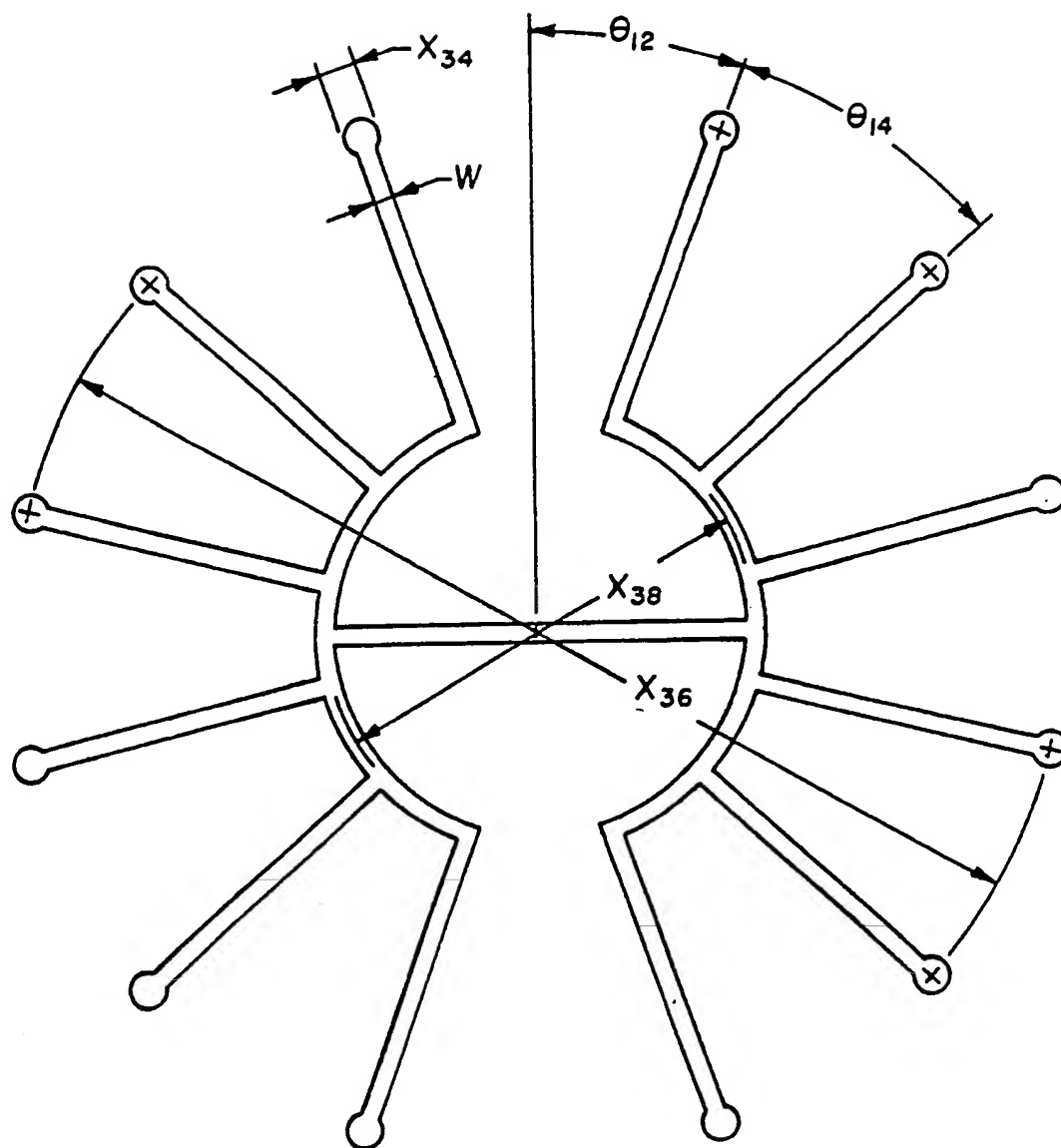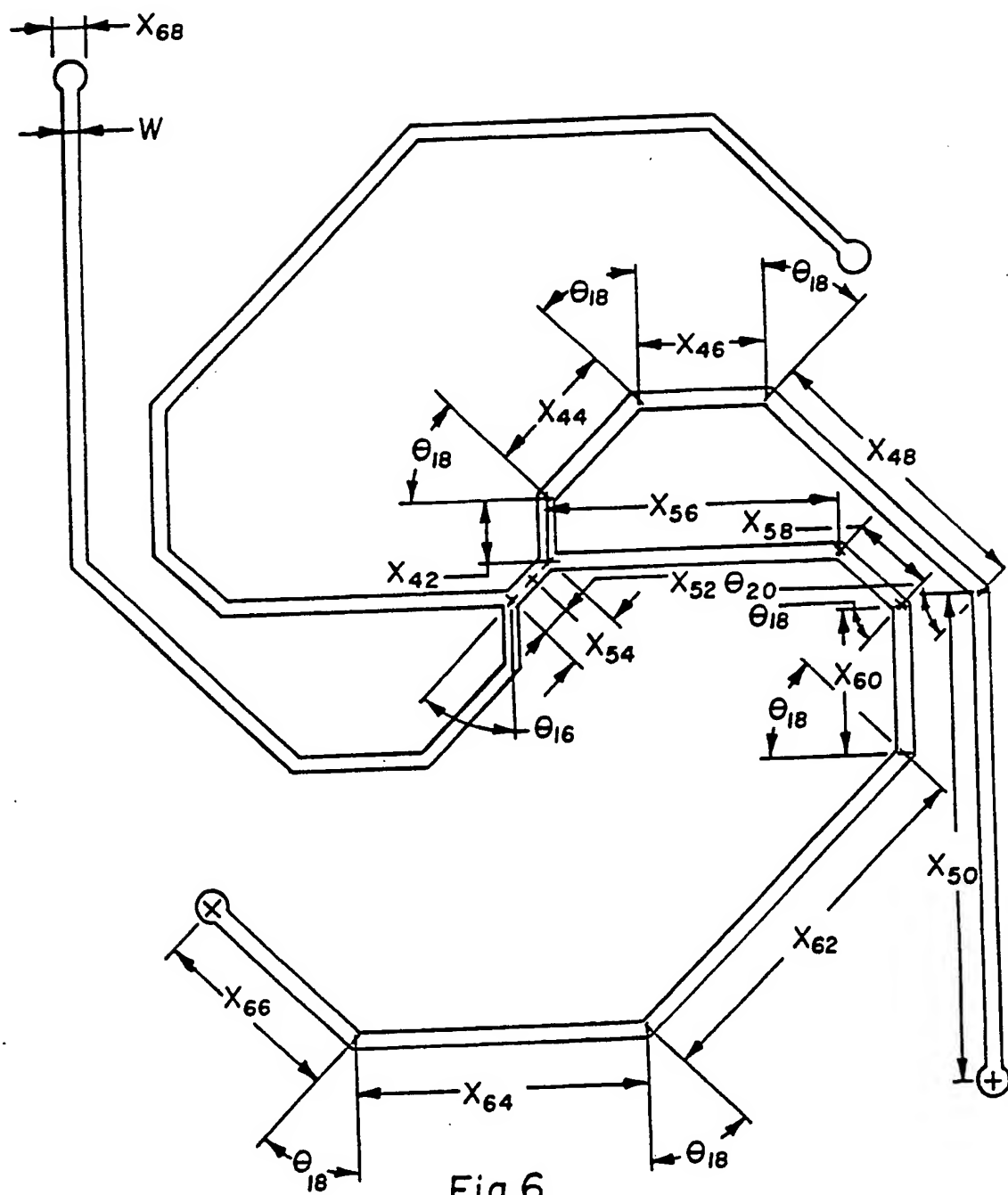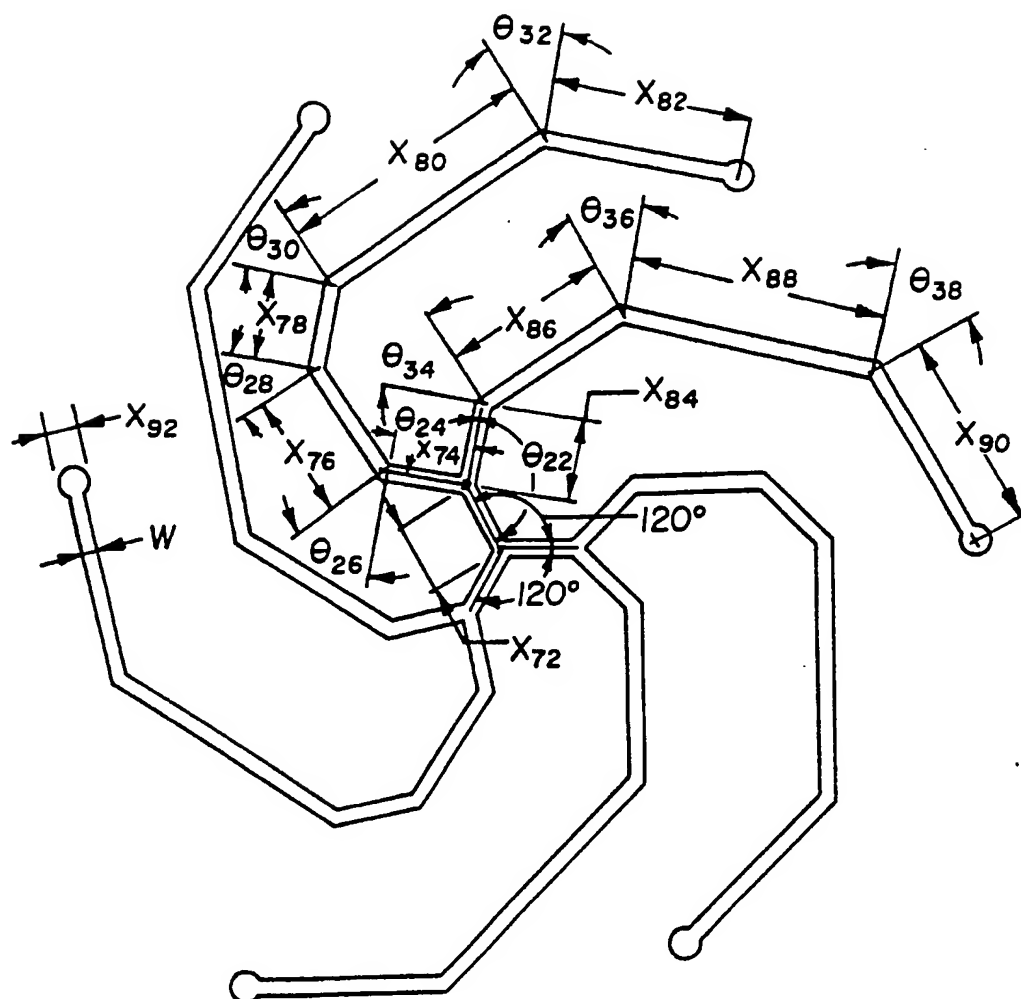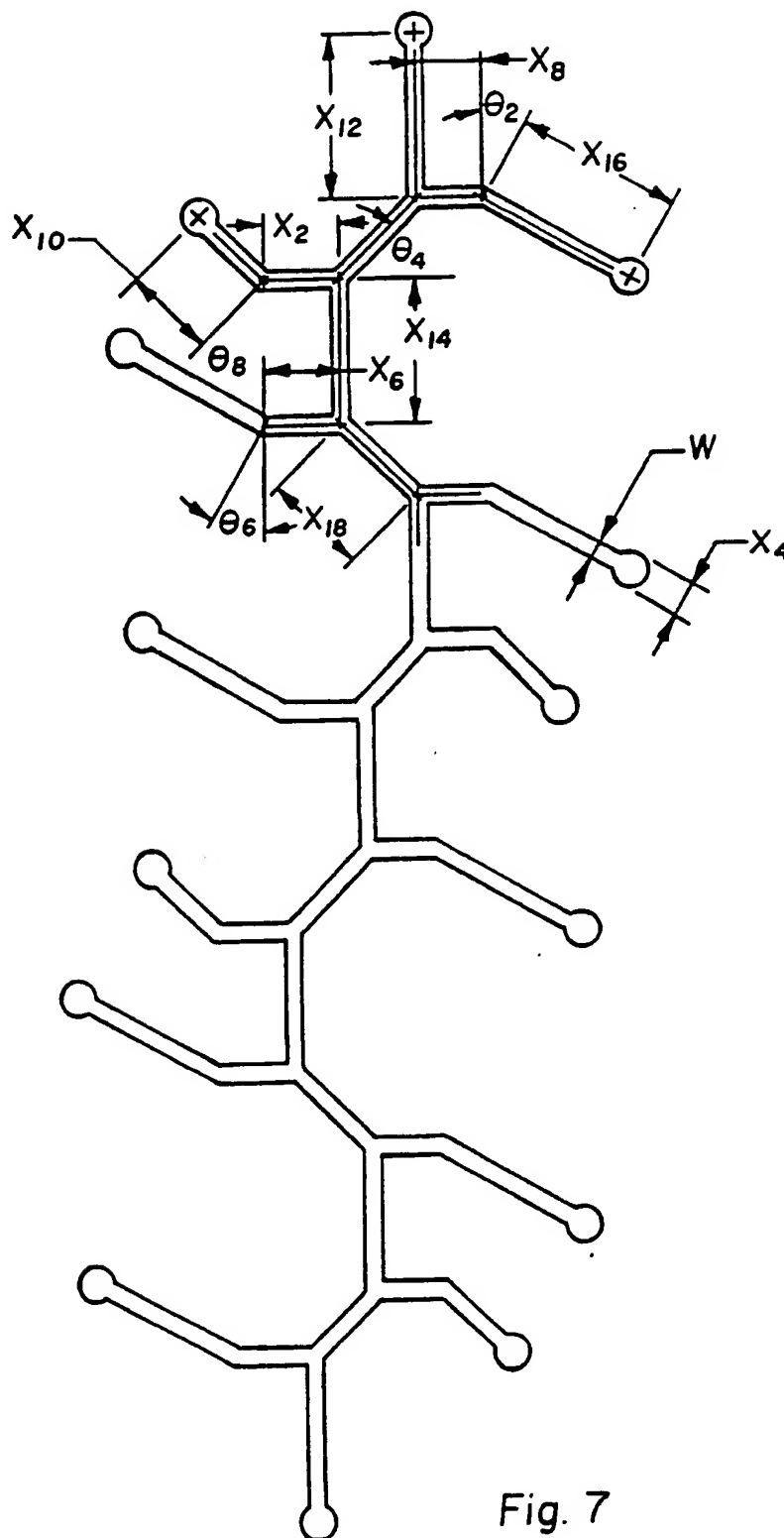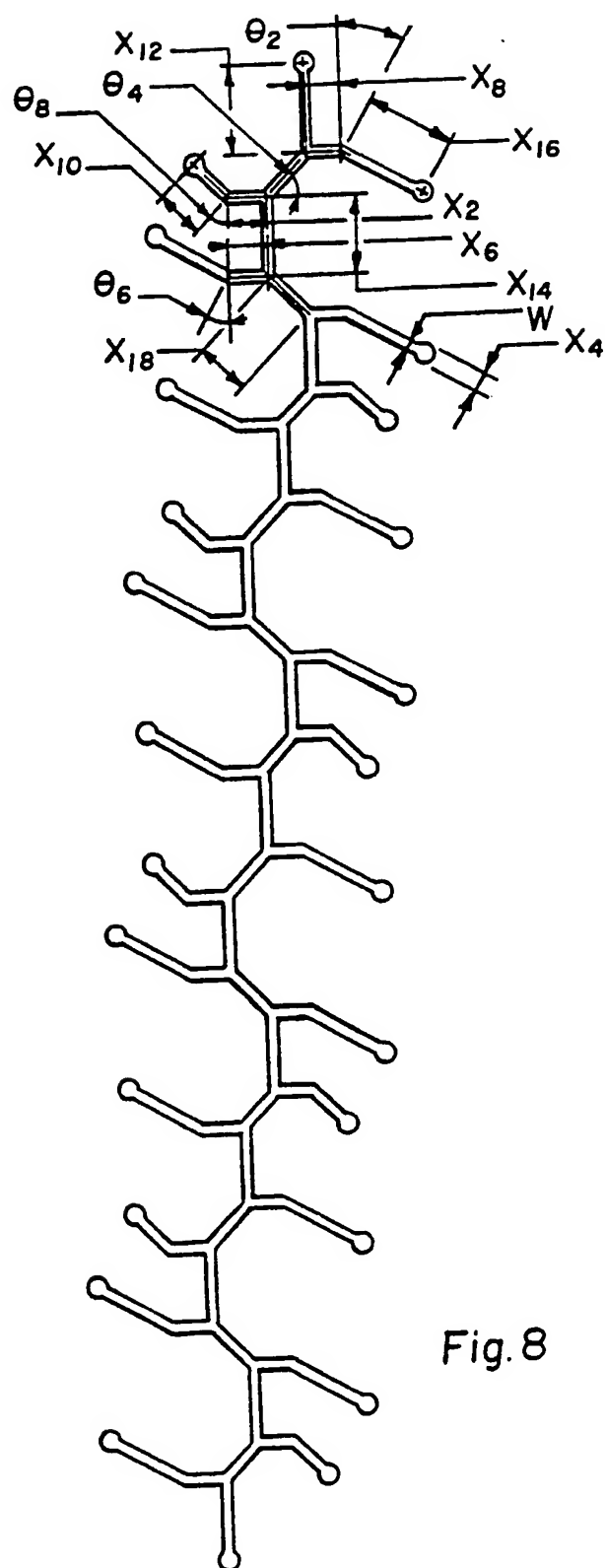
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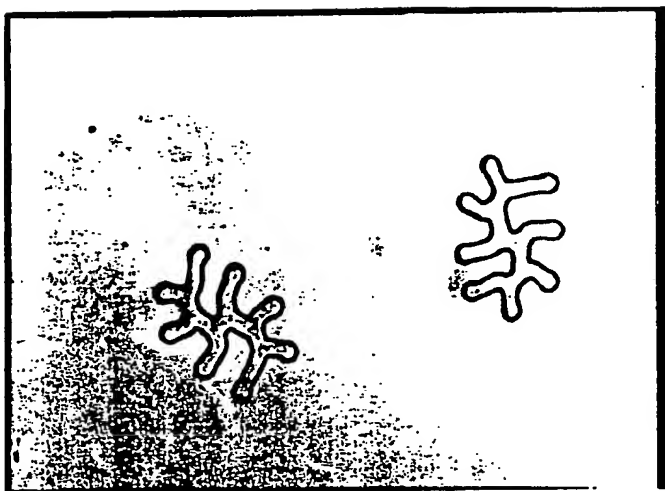
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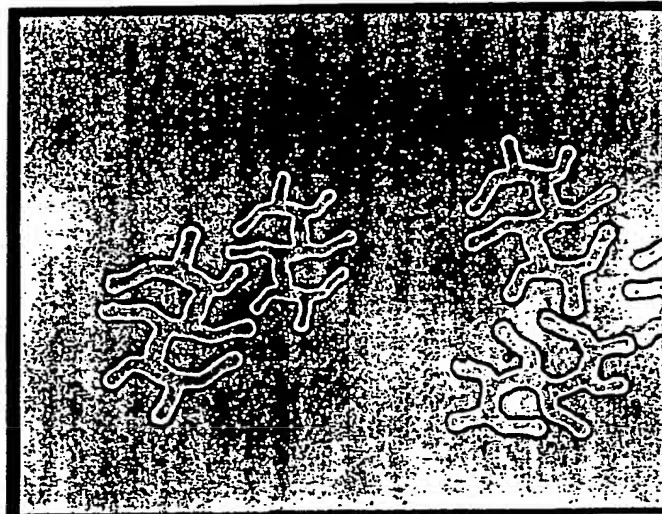
Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14
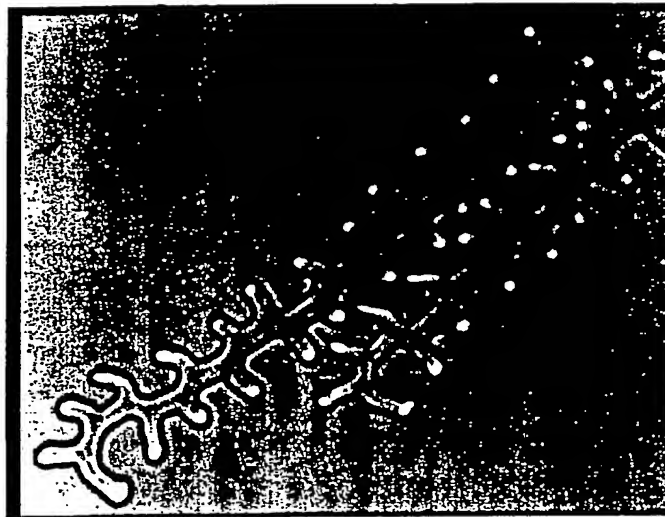
Fig. 15

Fig. 16

Fig. 17
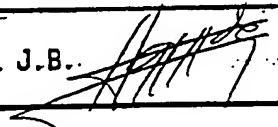
Fig. 17 B

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl: D01D5/253 ; A61L15/00 ; A61F13/15

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols		
Int.Cl. 5	D01D ;	A61L ;	A61F

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category[o]	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
P,&, Y	EP,A,0 391 814 (EASTMAN KODAK CO) 10 October 1990 the whole document cited in the application ---	1-25
Y	EP,A,0 188 091 (MINNESOTA MINING AND MANUFACTURING CO) 23 July 1986 the whole document cited in the application ---	1-25

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
22 OCTOBER 1991	0 5. 11. 91

International Searching Authority	Signature of Authorized Officer
EUROPEAN PATENT OFFICE	TARRIDA TORRELL J.B.

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0391814	10-10-90	AU-A-	5404090	05-11-90
		CN-A-	1046361	24-10-90
		WO-A-	9012130	18-10-90
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		JP-A-	61160483	21-07-86
		SU-A-	1424724	15-09-88
		US-A-	4985298	15-01-91

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